

1. A spin-valve sensor disposed between gap layers, comprising:
2 an antiferromagnetic pinning layer;
3 a pinned layer disposed to one side of the antiferromagnetic pinning layer;
4 a sensing layer;
5 a spacer layer disposed between the pinned layer and the sensing layer;
6 and
7 a gap layer disposed to one side of the antiferromagnetic pinning layer, the
8 gap layer comprising a plurality of oxidized metallic films.

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10 2. The spin-valve sensor of claim 1, wherein the gap layer comprises a
11 first gap layer disposed to one side of the antiferromagnetic pinning layer and further
12 comprising a second gap layer disposed to one side of the sensing layer; the first and second
13 gap layers comprising a plurality of oxidized metallic films.

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15 3. The spin-valve sensor of claim 1, wherein the gap layer is formed of a
16 plurality of *in-situ* oxidized metallic films.

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18 4. The spin-valve sensor of claim 2, wherein at least one of the first gap layer
19 and the second gap layer is formed of an *in-situ* oxidized metallic film.

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21 5. The spin-valve sensor of claim 2, wherein the first gap layer and the
22 second gap layer are each formed of a plurality of *in-situ* oxidized metallic films.

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24 6. The spin-valve sensor of claim 2, wherein the first gap layer and the
25 second gap layer are each formed of a plurality of *in-situ* oxidized Al metallic films.

1 7. The spin-valve sensor of claim 2, wherein the plurality of oxidized metallic
2 films has a cumulative thickness in a range of between about 50 Å and about 200 Å.
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4 8. The spin-valve sensor of claim 2, wherein the plurality of oxidized
5 metallic films has a cumulative thickness in a range of between about 50 Å and about 200
6 Å.
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8 9. The spin-valve sensor of claim 2, wherein each of the plurality of films has
9 a cumulative thickness of about 100 Å.
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11 10. The spin-valve sensor of claim 1, further a plurality of seed layers
12 disposed to one side of the antiferromagnetic pinning layer; the seed layers comprising an
13 Al₂O₃ film, a Ni-Cr-Fe film and a Ni-Fe film; the antiferromagnetic pinning layer formed
14 of a Pt-Mn film; the pinned layers formed of a Co-Fe film, Ru film, and a Co-Fe film; the
15 spacer layer formed of an oxygen-doped, *in-situ* oxidized Cu film; the sensing layer
16 formed of a Co-Fe film and a Ni-Fe film, and a cap layer formed of an *in-situ* oxidized
17 metallic film.
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19 11. The spin-valve sensor of claim 10, further comprising a partially oxidized
20 cap layer adjacent to the sensing layer.
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- 1 12. A disk drive system comprising:
2 a magnetic recording disk;
3 a spin-valve sensor for reading data recorded on the magnetic recording
4 disk, the spin-valve sensor comprising:
5 an antiferromagnetic pinning layer;
6 pinned layers formed disposed to the antiferromagnetic pinning
7 layer, the magnetizations of the pinned layers substantially fixed by the
8 antiferromagnetic pinning layer;
9 a sensing layer formed of ferromagnetic films adjacent to the
10 pinned layers, the sensing layers configured to have an electrical resistance
11 that changes in response to changes in magnetic flux through the sensing
12 layer; and
13 a cap layer disposed to one side of the sensing layers, the cap layer
14 formed of a partially *in-situ* oxidized metallic film having a thickness in a
15 range of between about 5 and about 15 Å;
16 a first gap layer disposed to one side of the antiferromagnetic pinning
17 layer, the first gap layer comprising a plurality of oxidized metallic films;
18 a second gap layer disposed to the cap layer, the second gap layer
19 comprising a plurality of oxidized metallic films;
20 an actuator for moving a read/write head comprising the spin-valve sensor
21 across the magnetic recording disk in order for the spin-valve sensor to access
22 different magnetically recorded data on the magnetic recording disk; and
23 a detector electrically coupled to the spin-valve sensor and configured to
24 detect changes in resistance of the spin-valve sensor caused by rotation of the
25 magnetization of the sensing layers relative to the fixed magnetizations of the
26 pinned layers in response to changing magnetic fields induced by the magnetically
27 recorded data.

1 13. A method of fabricating a spin-valve sensor, the method comprising:
2 forming an antiferromagnetic pinning layer;
3 forming pinned layers to one side of the antiferromagnetic pinning layer;
4 forming sensing layers;
5 forming a spacer layer disposed between the pinned layers and the sensing
6 layers; and
7 forming a cap layer disposed to one side of the sensing layers by
8 deposition and *in-situ* oxidation of a metallic film.

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10 14. The method of claim 13, further comprising forming first and second gap
11 layers, the forming first and second gap layers comprising depositing a metallic film and
12 *in-situ* oxidizing the metallic film.

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14 15. The method of claim 13, further comprising forming first and
15 second gap layers, the forming first and second gap layers comprising forming a plurality
16 of oxidized metallic films.

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18 16. The method of claim 15, wherein forming a plurality of oxidized
19 metallic films comprises forming a plurality of *in-situ* oxidized aluminum films, each
20 having a thickness in a range of between about 5 and about 15 Å.

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22 17. The method of claim 13, wherein the deposition and *in-situ*
23 oxidation of the metallic film comprises depositing the metallic film in a vacuum in a
24 deposition module and transferring the metallic film to an oxidation module also in a
25 vacuum and introducing an oxygen gas to the metallic film in the oxidation module in a
26 controlled environment.

1 18. The method of claim 17, wherein depositing a metallic film comprises
2 depositing an Al film.

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4 19. The method of claim 17, wherein the deposition and *in-situ* oxidation of
5 the metallic film comprises DC magnetron sputtering and *in-situ* oxidation for a time in a
6 range of between about 1 and about 100 minutes in an oxygen gas with a pressure in a
7 range of between about 0.1 and about 10 Torr.

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9 20. The method of claim 17, wherein introducing the oxygen gas
10 comprises introducing the oxygen gas with a pressure in a range of between about 0.5 and
11 5 Torr.

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13 21. The method of claim 17, wherein introducing the oxygen gas
14 comprises introducing the oxygen gas with a pressure in a range of between about 1 Torr
15 and about 3 Torr.

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17 22. The method of claim 17, wherein introducing the oxygen gas
18 comprises introducing the oxygen gas with a pressure of about 2 Torr.

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20 23. The method of claim 17, wherein introducing the oxygen gas
21 comprises introducing the oxygen gas for a period in a range of between about 4 and
22 about 12 minutes.

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24 24. The method of claim 17, wherein introducing the oxygen gas comprises
25 introducing the oxygen gas for a period in a range of between about 6 minutes and about
26 10 minutes.

1 25. The method of claim 17, wherein introducing the oxygen gas comprises
2 introducing the oxygen gas for a period of about 8 minutes.
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4 26. The method of claim 17, wherein introducing the oxygen gas is conducted
5 at a temperature of approximately ambient room temperature.
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